# Biocultural Restoration Guide for Protect and Preserve Hawai‘i

## Culturally Aligned and Community Engaged Invasive Species Removal Strategies for Pia Valley


Written by *graduate students* from the

University of Hawai‘i at Mānoa
**Department of Natural Resources and Environmental Management**

Samantha Shizuru, Alexis Stubbs, Ryan Ueunten

# Table of Contents

## Section 1. Introduction

# Welcome to this biocultural restoration guide for Pia Valley!

Pia Valley is one of the most significant valleys on the eastern side of O‘ahu, and it has so much potential for restoration. As you will see, Pia Valley is rich with *native species*, *engaged community members*, and *strong cultural significance*. Thus, this restoration guide is intended to assist the many people dedicated to revitalizing this important place. By restoring Pia Valley, Hawai‘i will be a better place for generations to come.

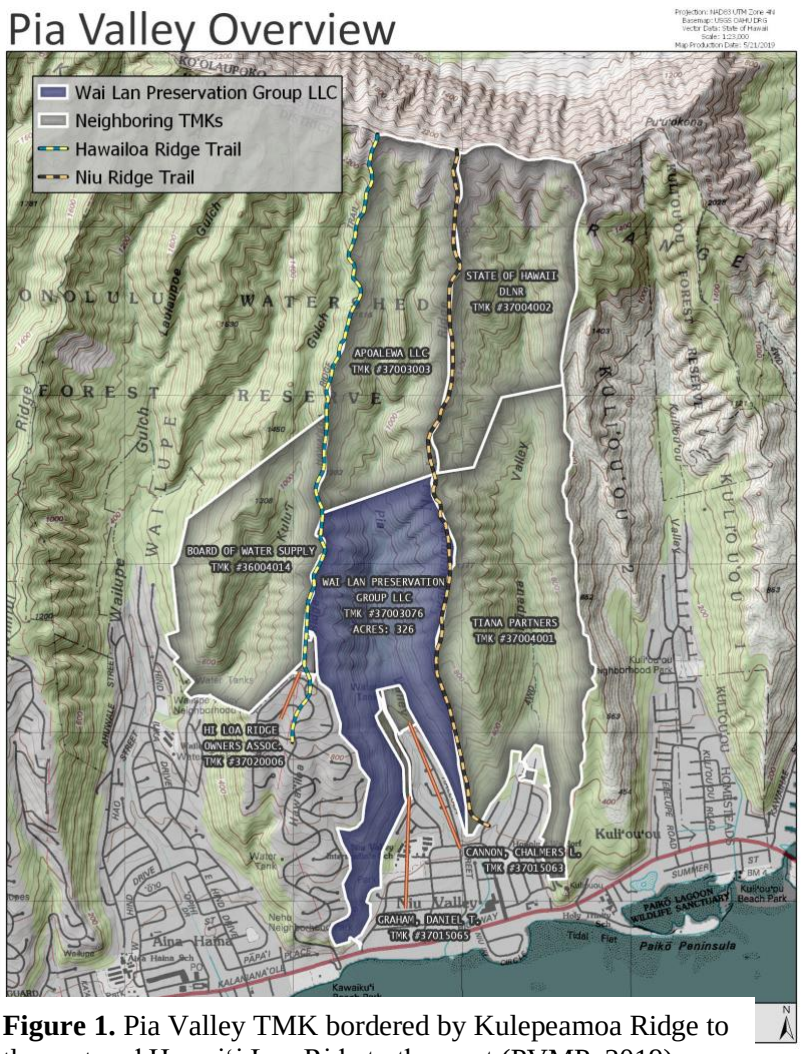


**Figure 1.** Pia Valley TMK bordered by Kulepeamoa Ridge to the east and Hawai‘i Loa Ride to the west (PVMP, 2019).

### *Pia Valley*

Pia Valley is a narrow and elevated leeward valley located in the 2,446-acre ahupua‘a (traditional land division) of Niu (TMK 37003076). It contains a unique lowland mesic ecosystem in the leeward Ko‘olau mountains and is home to many native flora and fauna. Pia Valley is bordered by Kulepeamoa Ridge to the east and Hawai‘i Loa Ridge to the west, and roughly one mile from the coast of Maunalua Bay (Figure 1). The higher regions of Pia Valley, extending from Hawai‘i Loa up to the Ko‘olau crest in Hawai‘i Kai are part of the State of Hawai‘i Natural Area Reserve System (NARS) and is considered a critical habitat. There are records of 29 rare species found in the area or are historically known from the area. Also, this region is federally designated as critical habitat for 17 species.

**Figure 2.** Shot overlooking Niu ahupuaʻa (Photo by Miles Thomas).

## *Protect and Preserve Hawai'i, A Nonprofit Organization*

Pia Valley once flourished with robust populations of rare endemic and indigenous flora and fauna but is now becoming increasingly threatened by a rapid take-over of invasive species. The robustness of Pia Valley is what traditionally drew Native Hawaiians and other users to the area. Pia was a place that provided resources, such as food, timber and medicine. Koʻokoʻolau (*Bidens sandvicensis*), ʻuhaloa (*Waltheria indica*), kalo (*Colocasia esculenta*), and ʻuala (*Ipomea batatas)* are just to name a few. The native ecosystems in the upper regions of Pia Valley are still intact, but the lower central regions are experiencing a rapid takeover of invasive species and decline in native vegetation. This may be attributed to a lack of proper land stewardship and disengaged communities.

The nonprofit organization, Protect and Preserve Hawaiʻi, recently acquired a 300-acre parcel in Pia Valley with a mission to "*protect and preserve Pia Valley's wildlife, forests, streams, and Hawaiian culture, and engage area residents in its management*". The recently published Pia Valley Forest Restoration and Management Plan (PVMP) specifically outlines three criteria for management: Ecological, Cultural and Community/Educational. This biocultural restoration guide will assist in the development of each of these three criteria's but will primarily focus on the ecological management section of the PVMP.

According to the PVMP, the key strategy for ecological management is to:

**"*Develop a plan for the area utilizing appropriately sized restoration plots to systematically restore the diversity and health of the native forest and stream, while paying attention to preserving rare and endangered species*".**

**Figure 3.** Maua, *Xylosma hawaiiense* (Photo by Miles Thomas).

To help implement this strategy, the executive director of Protect and Preserve Hawai‘i and a group of master’s students at the UH Mānoa’s department of Natural Resources and Environmental Management (NREM) identified that invasive species removal is imperative for restoration. Thus, these students have constructed this guide using a biocultural restoration framework to assist with the removal of invasive species. The overarching objective of this biocultural restoration guide is to provide guidance for invasive species removal at two sites of Pia Valley, using culturally aligned invasive species removal techniques and management strategies.

## Section 2. The Framework

### *What is Biocultural Restoration?*

Biocultural restoration is based on the concept that humans and nature are intimately linked. In particular, the physical, spiritual, and cultural interactions that humans have with nature impact the overall health of the surrounding environment. Similarly, the many ecological processes, services, and functions of the environment impact the overall health and well-being of people. Thus, biocultural restoration is the revival of both *environmental* and *human cultural* aspects of a place.

### *Applicability to Hawai‘i*

Although biocultural restoration is a relatively new term in Hawai‘i (Chang et al. 2019), this concept is very applicable because Hawai‘i is home to a rich diversity of both native ecosystems and native culture. Kānaka maoli (Native Hawaiians) are the original people of these islands, and for centuries, have developed intimate and reciprocal relationships with their environment. In fact, with concepts of conservation, protection, and respect of the natural world interwoven into every aspect of the Hawaiian lifestyle (Change et al. 2019), kānaka maoli found ways to thrive while living in balance with the land. This restoration guide recognizes the great importance of Hawaiian knowledge and identifies *key cultural values* to enrich the restoration of Pia Valley. This guide also contains important *thoughts*, *stories*, and *lessons* collected from the community to appropriately inform the restoration efforts. Ultimately, this biocultural restoration guide will not

only improve restoration strategies for Pia Valley, but also achieve impactful community engagement, leading to greater long-term restoration success.

## *Hawaiian Cultural Values of People and Land*

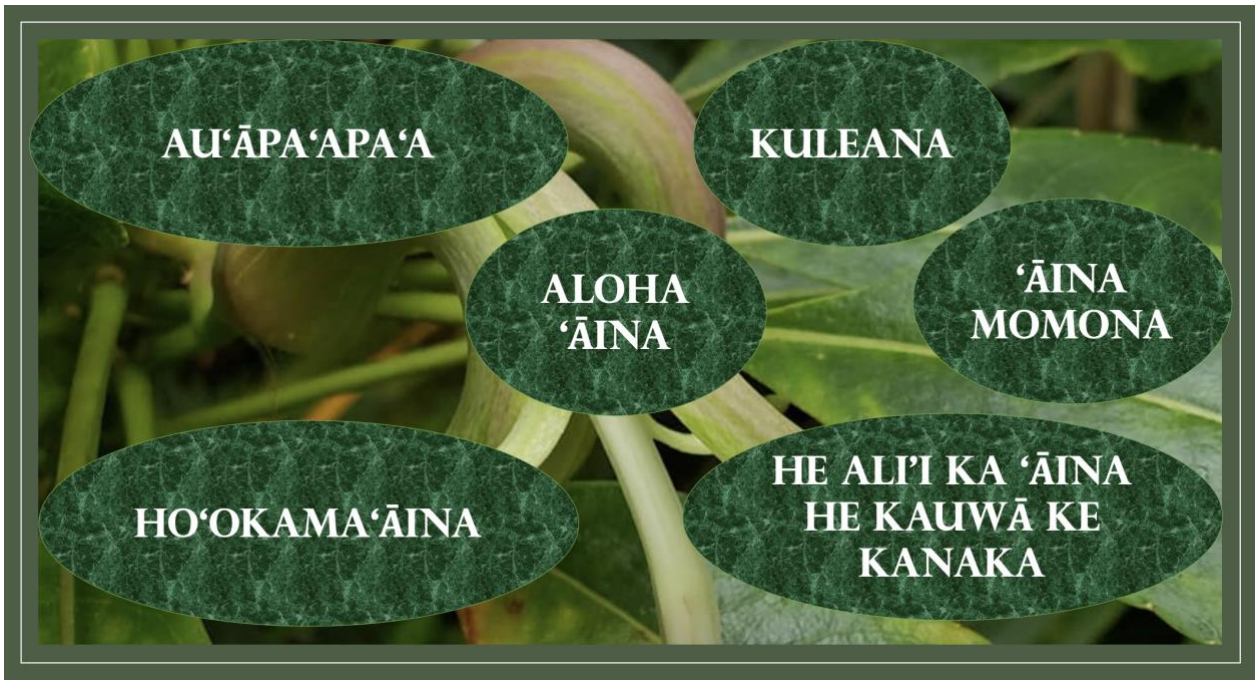


**Figure 4.** Overarching Hawaiian Cultural Values identified to guide this Biocultural Restoration Guide

After reviewing cultural texts, published papers, and interviews with community members and cultural practitioners, key cultural values were identified to set the foundation of restoration work in Pia Valley. Due to the scope of this guide, however, the descriptions provided for each identified value do not fully detail the multiple layers and meanings that they each possess. Nor are all pertinent Hawaiian values included. These values were chosen because they closely align with biocultural restoration work throughout Hawai‘i, and also they exemplify the cultural connections the people of Maunalua have to Pia Valley. Any future restoration projects in Pia Valley should expand upon these listed values. For now, the next step is to translate these values and principles into actionable restoration efforts.

Note, each listed value below stems from the overarching concept of ***Aloha ‘Āina***. This concept is one of the most fundamental principles in Hawaiian ideology. While the meaning of Aloha ‘Āina is often translated as “love for the land”, this concept is much more complex (Beamer 2014). For instance, just the word ‘āina itself is often viewed as land and resources, yet ‘āina more accurately translates to “that which feeds” (Morishge et al. 2018). This means ‘āina is interconnected with people (Beamer 2014), and it includes the physical, emotional, and spiritual sustenance that land provides (Morishige et al. 2018). At its core, Aloha ‘Āina is a deep sense of appreciation for the land that feeds us, and it is an active action that needs to be put into practice rather than a state of being (Beamer 2014). For kānaka maoli, Aloha ‘Āina is the reason why the health of Hawai‘i’s environment is inherently and reciprocally connected to the people.

**ʻĀina Momona** - This value consists of the words ʻāina and momona (fat, fertile, rich, as in soil, fruitful), which collectively means "fat land" or "abundant land". Through careful resource management of landscapes from mountain to the sea, ʻĀina Momona is a state of richness and productivity of the land over generations of use. Moreover, ʻĀina Momona is often described as a long-term goal for biocultural restoration, since this value entails a perpetual abundance of resources that is sustainably used. ʻĀina Momona also involves rich community engagement, since an abundance of resources is best achieved through strong relationships of people to place.
*(Morishige et al. 2018 & Winter et al. 2018)*

**Kuleana** - This value translates to "rights" and "responsibilities". In the context of Aloha ʻĀina, however, Kuleana means to recognize and take on the responsibilities of caring for the land. While Kuleana also includes the right to benefit from Hawaiʻi's environment (for food, recreation, etc.), this value more deeply instructs us to protect and ensure an abundance of resources for future generations.
*(Chang et al. 2019, Kurashima et al. 2018)*

**Hoʻokamaʻāina** - In biocultural restoration, Hoʻokamaʻāina is a process of becoming familiar with a place on a physical, spiritual, and emotional level. Hoʻokamaʻāina can be achieved through "regular visits to a place over multiple times over the year and observing the surroundings". Also, by speaking the traditional place names, conducting proper protocols such as oli (chanting), and learning about the place through cultural texts and lineal descendants, Hoʻokamaʻāina means building intimate relationships to a place. *(Kurashima et al. 2018)*

**Auʻāpaʻapaʻa** - This concept is defined as the "ancestral ways of knowing and time keeping". Similar to Hoʻokamaʻāina, Auʻāpaʻapaʻa is a principle attained through years of observing environmental relationships and natural cycles to keep track of time. Examples of Auʻāpaʻapaʻa include "using the rising and setting of the sun to reference time or using cyclic phases of the moon to develop a calendar for resource management". In biocultural restoration, Auʻāpaʻapaʻa is knowing the environmental changes through generations of observations, which can lead to better decision making and management.
*(Kapa-Oliveira 2014)*

**"He aliʻi ka ʻāina, he kauwā ke kanaka"** - This ʻōlelo noʻeau (Hawaiian proverb) means the "land is chief, and man is the servant". In the Hawaiian worldview, land and resources are valued much more than any person. In fact, ʻāina is the elder ancestor to kānaka maoli, so ʻāina must be treated in a similar way as any kūpuna (elder) would be treated. In order to maintain this relationship and ensure balance between people and land, kānāwai and kapu (laws and restrictions) were placed for all to follow.
*(Kurashima et al. 2018)*

## *Voices from the Community: The Significance of Pia Valley*

One of the best ways to learn about a place is through the stories and experiences of people of the area. Thus, residents, teachers, volunteers, and community members were interviewed, and the following below are important themes that were shared. Hopefully, these community voices will lead to more appropriate restoration efforts in Pia Valley.

Sense of Place - One of the most prevailing themes throughout the interviews is recognizing a sense of place. This means knowing "*all of the ecosystems, mauka to makai, plants, animals, winds, and moon cycles"* and "*taking care of your ahupua'a and community"*. Furthermore, sense of place also means understanding the historical and cultural connections of the place.

- "*Without knowing the historical background, I don't think you can bring to fruition the true nature of the area.*"

Thus, interviewees talked about the cultural significance of Pia Valley. For example, the coastal areas were rich in fishponds (i.e. Kalauha'iha'i and Kupapa fishponds), and lava tubes that stretch from mauka to makai brought freshwater into these fishponds. Also, a heiau was constructed on Kulepeamoa Ridge, and throughout the Pia Valley walls, many caves contain sacred burial grounds for kānaka maoli. One interviewee even expressed how the Maunalua area was significant for traditional navigation. In summary, the restoration of Pia Valley means to perpetuate and protect these sacred yet fragile cultural treasures.

Interviewees additionally expressed that a sense of place means establishing relationships with the place.

- *"You have to get to know the area better and create a connection in order to make better decisions...investing in the area and working in the area...helps to appreciate the work more."*

- *"To cherish the natural foundation...what more would you want to do to provide opportunities for the next generation?"*

Lastly, the most important aspect of sense of place relates back to the value of Kuleana. For the interviewees, sense place means recognizing their responsibility to protect and restore their lands and resources.

- *"The reason why people are driven to create positive change...why people developed deep relationships to place and a sense of 'āina is because they are realizing that the resources are becoming more scarce. We don't see as many fish, or native birds, or trees… as areas become more and more developed, we lose more of our natural land. So we focus on concepts like sustainability or abundance of resources… If we don't manage or take care of our resources now, then we're going to lose them."*

- *"This whole side [of Pia Valley] has been degraded for so long… we have these little kīpuka's (pockets of native ecosystem) left… a little bit of time left for these remaining elepaio and stands of native trees that are barely hanging on in the back where people haven't grazed upon. That's why it is important to me, because I see how doable it is. We did it at the fishponds and we can bring it up mauka too."*

Maunalua Community - Interviewees expressed how special the people of Maunalua are in caring for their community. They described the people of Maunalua as "*active*" and "*responsive*" in making their environment better, and also how they are a "*tight knit community that supports each other*." Furthermore, interviewees shared how they fought alongside their community to protect important places like Paikō bird sanctuary, Kalauha'iha'i and Kānewai fishponds, and stopped the construction of a film studio in the back of Kuli'ou'ou. These are the people that will dedicate their time, energy, and passion to restore Pia Valley.

- "*People who continuously volunteer in Maunalua are primarily residences of the Maunalua community. They are students from elementary to college, parents, teachers, kūpuna, and multigenerational families who have lived and grown up within the area... "*

- " *The Maunalua Bay area still has families that have lived here for generations... still have ancestral connections to place and gatherings…to care for the environment, it's almost common sense."*

Importance of Wai - Wai, or freshwater, is clearly the most valuable resource in any place throughout Hawai'i and the rest of the world. Interviewees often talked about how important protecting wai is for the restoration of Pia Valley.

- "*Water is crucial! Our kūpuna are really amazing because they say waiwai. Waiwai is richness, or to be rich… in ancient times, our rich came from water which gave us life."*

- "*People follow the water. Our chiefs followed the water, and much of this area [of Maunalua] was rich with chiefs… so this means we know there's water and the watersheds must've been amazing!"*

Interviewees also shared cultural concepts of wai in the Maunalua area. For example, one person shared how "*Kānewai spring (in Kuli'ou'ou) is the piko (umbilical cord, connection) of mauka to makai."* Recent developments, however, have severed this water connection and "*ruined the ecosystem and the nearshore area.*"

Lastly, when asked about the significance of restoring the Pia Valley ecosystem, one interviewee shared the 'ōlelo no'eau (Hawaiian proverb): *Hahai nō ka ua i ka ulu lā'au* - "Rain always follows the forest". Thus, restoring native forests will help return precious freshwater back to the lands of Maunalua.

- " *I would like to see the rain come back… when u see the clouds come, when they hit Niu Valley, there is so much heat from all the invasives and the highway and it radiates*

*up...Once the clouds hit Niu Valley, they go way back towards the Koʻolaus in the native forest and they dont drop rain."*

Challenges of Restoration - When asked about the restoration efforts of Pia Valley, interviewees discussed multiple concerns. Therefore, understanding and addressing these concerns will achieve greater outcomes of restoration.

- *"Herbicide is the only effective way of controlling invasives, but how do you do it in a pono (right, balanced) way?"*
- *"Herbicide should be used away from streams…"*
- *"Teenagers going up having fires, partying… That's a threat to our native ecosystem. We need someone watching over everything."*
- "*Don't make it look too inviting, otherwise you will invite the whole world and the valley is not set up to handle that."*
- *"Lots of cultural sites, so shouldn't be overrun... These sites are fragile, so who we share these sites with is important! Tourism should stay out. This is about sustainability and community."*
- *"What happens after restoration? Does that mean gathering? Hiking? What can the community use?"*

Visions of a Restored Pia Valley - Lastly, interviewees shared their own visions of what restoration looks like in Pia Valley. For example, suggested restoration strategies include deploying strategic fencing to control ungulates, using a kīpuka style of restoration (expanding upon areas of native abundance), and establishing a diversity of native plants such as common and endangered species.

- *"Pia Valley could become a refugia for species, especially ones found in the Southern Koʻolaus…[like] a segway for endangered plants.*"
- *"This [Pia Valley] project can help ecosystem restoration for other valleys in the Maunalua area…"*

For interviewees, restoration also means using the available resources on the land.

- *"There are so many resources, so start using them and managing them. Doesn't matter if it's native or nonnative [species], they are still resources. The schools and families from Niu [Valley] would be leading and benefiting from that effort.*"

- *"Grow medicine! When we grow all our resources, all our native birds and things will come back."*

Finally, interviewees expressed the importance of collaboration and working with the community to restore Pia Valley.

- "*It's about bringing community, conservation, and culture together to build bridges not walls.*"

- *"Education is a big component to restoration… learning activities should be implemented, like establishing an interpretive trail."*

- *"Many students choose marine debris for their local conservation project... Working with Protect & Preserve Hawai'i will give more opportunities for students to see the impact that they're making by actions such as invasive species removal and planting native plants."*

- *"To control pigs, work with the hunters... they are part of the effort, not a separate effort. [Hunting] is a really valuable practice... The people that know the valley the best are the hunters...so they should be a part of any effort that happens."*

- *"It's a kākou thing… we need to get as much manpower as possible."*

**Figure 5.** Lehua papa, *Metrosideros rugosa* (Photo by Miles Thomas).

## Section 3. Target Sites and Weed Assessments

### *Target Sites*

This restoration guide specifically focuses on invasive species removal at two sites in Pia Valley. The goal for these two sites is that they will serve as examples of restoration for the rest of the 300-acre parcel. These two sites were chosen based on conversations with the landowner, current restoration efforts already taking place, and ability to be scaled up later.

### *A‘ali‘i Grove*

As the name suggests, this site is defined by an isolated stand of a‘ali‘i plants (*Dodonea viscosa)*, located among the invasive dominated landscape. A‘ali‘i Grove has a partially rocky terrain, and it is situated on the flat valley floor on the eastern side (Koko Head side) of the trail. This site was selected because it is located no more than 10 minutes from the trailhead, so people of all ages can access this site. Also, restoration of this site aligns with the kīpuka style of restoration (expanding upon areas of native abundance). Since this site can receive frequent maintenance from volunteers (especially families with children), A‘ali‘i Grove has great potential to be the main restoration area and an ideal “entrance” for Pia Valley.

**Figure 6.** A‘ali‘i Grove (Picture by Ryan Ueunten).

## *Red Slope*

This site is the remnants of an old scar located on the slopes of Kulepeamoa Ridge (eastern side of Pia Valley). Though the majority of this area consists of exposed red soil, native vegetation is still present and continues to establish. This site has steep terrain, so soil erosion is a major hazard for restoration of this area. Red Slope was selected because this site contains several established native species and restoration work is already occurring. Since this site is located approximately 30 minutes from the trail head, Red Slope is accessible to more experienced volunteers that can handle steep terrain. In the end, Red Slop is envisioned to be a site of intensive restoration and managed by a few but skilled volunteers.

**Figure 7.** Red Slope (Photo by Alexis Stubbs).

## *Survey Analysis of Invasive Species*

A preliminary plant assessment was conducted and recorded in the *Pia Valley Forest Restoration and Management Plan*. This plant assessment includes the identification of both native and non-native plant species that were observed along the trail through Pia Valley. For this biocultural restoration guide, however, a new weed survey analysis was conducted specifically at the two target sites. This new weed survey analysis involved observing and recording non-native plant species along the trailhead that ran through the two target sites in a 2-meter radius. Listed in Tables are each of the recorded plant species and also their respective rank of invasiveness based on the PIER Weed Risk Assessment Score (WRA Score).

## *Weed Risk Assessment Score*

The Pacific Island Ecosystems at Risk project (PIER) is a compilation of referenced information on alien plant species that have a known or potential threat to Pacific Island ecosystems. PIER provides a listing and description of alien plant species in the Pacific region. Each plant profile includes both the common and scientific name of the species, a description, control methods cited in literature, photographs, and risk assessment information.

The Weed Risk Assessment Score (WRA Score) is based on biological information gathered from scientific literature and other plant sources and provides a rating of species' invasiveness in the Pacific. A rating of "low risk" indicates that there is a low probability that the plant will become a serious pest, and a rating of "high risk" indicates that the plant poses a high risk of being invasive.

The WRA Sores are only predictions of invasiveness for plant species that have been documented and studied in the literature. Some plant species do not have enough information to determine whether it is a low or high risk, so a score of "evaluate" is given to indicate an inconclusive score. Moreover, this assessment does not identify the current distribution of each plant species in the Pacific, so the actual impacts of each species is not known. Although there are limitations, the PIER project is still a useful tool for both resource managers and the public because it provides collective data on non-native plant species that may be a threat to the ecosystem currently or in the future.

| Common Name | Scientific Name | Family | WRA Score | Risk |
|---|---|---|---|---|
| Partridge pea | *Chaemascistra nictitans* | Fabaceae | 0 | Low risk |
| Fukien tea | *Ehretia microphylla [Syn. Carmona retusa]* | Boraginaceae | 4 | Evaluate |
| Haole koa | *Leucaena leucocephala* | Fabaceae | 15 | High risk |
| Guinea grass | *Megathyrsus maximus* | Poaceae | 17 | High risk |
| Blue porterweed | *Stachytarpheta jamaicensis* | Verbenaceae | 0 | Low risk |

**Table 1.** WRA Scores of non-native plant species at A‘ali‘i Grove

| Common Name | Scientific Name | Family | WRA Score | Risk |
|---|---|---|---|---|
| Bamboo orchid | *Arundina graminifolia* | Orchidaceae | 11 | High risk |
| Soapbush | *Clidemia hirta* | Melastomataceae | 27 | High risk |
| Hairy horsetail | *Conyza bonariensis* | Asteraceae | 0 | Low risk |
| Little ironweed | *Cyanthillium cinereum* | Asteraceae | 0 | Low risk |
| Lilac tasselflower | *Emilia sonchifolia* | Asteraceae | 0 | Low risk |
| Guinea grass | *Megathyrsis maximus* | Poaceae | 17 | High risk |
| Sourbush | *Pluchea carolinensis* | Asteraceae | 15 | High risk |
| Strawberry guava | *Psidium cattleianum* | Myrtaceae | 18 | High risk |
| Octopus tree | *Schefflera actinophylla* | Araliaceae | 13 | High risk |
| Christmas berry | *Schinus terbinthifolius* | Anacardiaceae | 19 | High risk |
| Blue porterweed | *Stachytarpheta jamaicensis* | Verbenaceae | 0 | Low risk |
| Java plum | *Syzygium cumini* | Myrtaceae | 9 | High risk |

**Table 2.** WRA Scores of non-native plant species at Red Slope

## Section 4. Identification and Application of Invasive Species Removal Techniques

*Non-Chemical Removal Techniques*

### 1. Organic Mulching

Organic mulching is a technique that involves the spreading of permeable material around newly out planted plants, or across the entire area of restoration. Organic mulching material can be leaves, grass clippings, straw cuttings, or wood chips. This strategy is primarily used to prevent competing vegetation from reappearing after being removed.

Advantages

- Controls weed growth
- Insulates and stabilizes soil temperatures
- Adds nutrients to the soil
- Very effective against shade intolerant weeds

Disadvantages

- Requires long amounts of time (months to years)
- Can be costly to buy mulching material
- Prevents native seedlings from germinating
- Mulching material could introduce new pests

**Figure 8.** Organic Mulching
Photo Credit: Alabama University

### 2. Manual Hand Pulling

Manual hand pulling of weeds involves removing both seedlings and saplings from the ground without the use of any tools. When using this technique, it is important to remove uprooted plant material from the ground to prevent parts from re-rooting and germinating.

Advantages

- Requires little to no costs
- Useful near sensitive or endangered plants

Disadvantages

- May cause soil disturbance and increase wind/rain erosion
- Requires intensive follow up to prevent reinvasion of non-native species
- Long-term persistent seed banks can still be present in the area
- Time consuming when applied over large area

**Figure 9.** Manual hand pulling of weeds
Photo Credit: UH Manoa

## 3. Use of Hand Tools/Power Tools

Hand tools and/or power tools are commonly used on woody and more established weeds. Hand tools can include clippers, handsaws, and machetes. Power tools can include chainsaws and weed whackers. The use of both types of tools involves cutting the plant about 1-2 inches above the base. This technique may be complemented with the use of herbicide to prevent regrowth, but it is not required.

Advantages

- Efficiently removes plants
- Applicable over large areas
- Some tools are relatively cheap ($10-$100 range)

Disadvantages

- Involves a high risk of injury (especially handsaws, machetes, and power tools)
- Power tools can be costly ($100-$1000 range)
- Requires tool maintenance

**Figure 10.** Use of power tools for weed removal
Photo Credit: UH Manoa

## 4. Soil Solarization

Soil solarization is a technique that places a cover (e.g. black or clear plastic) over the soil surface to entrap heat and increase soil temperatures. An increase of temperature is intended to kill plants, seeds, pathogens, and insects that are trapped underneath. It is recommended to use this technique during the summer months when temperatures are higher and with wet soils.

Advantages

- Effective at preventing aggressive weed growth
- Retains soil moisture underneath covering
- Effective around newly out planted plants

Disadvantages

- Involves the use of plastic which can break apart after years of use
- Materials can be costly

**Figure 11.** Soil Solarization
Photo Credit: CTAHR, UH Manoa

*Chemical Removal Techniques*

Listed below are some of the most common and applicable methods of chemical removal for Pia Valley. The overall advantages and disadvantages of chemical removal include:

Advantages

- Highly effective and efficient at removing weeds
- Applicable over large areas
- Usage must abide by strict local, state, and federal regulations

Disadvantages

- Misuse can cause serious environmental and health concerns
- Unintentional application may harm native species
- Certain pesticides require certification to apply
- Can be costly

## 1. Clip and Drip

This technique involves using either a handsaw or clippers to cut the weed 1-2 inches above the base of the stem, and then thoroughly applying herbicide to the entire cut area. These are recommended herbicide mixtures based on the types of weeds in the proposed restoration site:

- Garlon 4 (20%) with Biodiesel

This mixture is used on woody species with either an applicator bottle or drip bottle

- Garlon 4 (40%) with Biodiesel

This mixture is recommended specifically for Haole koa (*Leucaena leucocephala*)

**Figure 12.** Tip Clipping
Photo Credit: WikiHow

## 2. Girdling

Girdling is used to control trees or shrubs with a single trunk. The first step of this technique is to cut parallel lines about three or more inches apart around the circumference of the tree using a knife or handsaw. The second step is to expose the vascular cambium of the tree, and lastly, apply herbicide around the entire exposed circumference. This technique is effective against pines, some oaks, and some maples. The recommended herbicide mixture is Garlon 4 (20%) with Biodiesel.

**Figure 13.** Girdling
Photo Credit: OANRP

## 3. Foliar Spray

This technique involves using either a hand pump or backpack sprayer to coat the foliage with herbicide. Foliar spray is typically used for treating invasive grass. It is recommended to time foliar sprays when the new growth of the grass appears. Similar to the clip and drip method, these are recommended herbicide mixtures based on the density of non-targeted vegetation in the restoration site:

**Figure 14.** Foliar Spray
Photo Credit: UH Manoa

- Ranger Pro (2%, 1%, or 0.5%) + blue dye (10 mL/gal. 2 mL/gal) in water

This mixture is specifically for grass control. The lower the dilution rate, the less chance of non-target impact to native vegetation

- Fusilade DX (0.58% or 22 mL/gal) + Surfactant (0.4% or 15 mL/gal) + blue dye (110 mL/gal or 2 mL/L) in water

This mixture is also specifically for grass control. It is effective for areas where there is a need to minimize non-target impacts.

## 4. Incision Point Application (IPA)

IPA involves making a small incision at the base of the tree and applying a micro-dose of herbicide directly into the exposed vascular system of the wood plant species. A syringe or a dropper can be used to inject the herbicide. A sharp tool such as a hatchet can be used to create the incision into the base.

**Figure 15.** Incision Point Application
Photo Credit: CTAHR, UH Manoa

***NOTE: When using any herbicide, you must follow all instructions on the herbicide label.**

*Management Strategies*

## 1. Kīpuka Style Restoration

Kīpuka is a Hawaiian term that is typically used to describe the last remaining intact forests after a lava flow. A kīpuka does not have to be large in area, but they naturally contain the oldest remaining native ecosystems in the area. In terms of ecological restoration, kīpuka style restoration means directing restoration efforts within the last remaining pockets of intact native ecosystems. So just as plants in a natural kīpuka supply the first seeds of regrowth after a lava flow, the goal of kīpuka style restoration is to not only protect the intact native ecosystems, but also eventually spread native ecosystems throughout an invasive dominated area.

## 2. Hybrid Restoration Approach

Hybrid restoration is an interdisciplinary approach that restores ecological, social, and cultural needs that are valued by community members (Burnett et al. 2019). This approach focuses on restoring both native and non-native (i.e. Polynesian introduced) species, which requires less cost than complete native ecosystem restoration (Burnett et al. 2019). Polynesian introduced species are culturally valuable and also have a low risk of invasiveness based on the PIER weed risk assessment. Burnett et al. (2019) demonstrate that the integration of both native and non-native species increases both functional trait diversity and ecological resilience to disturbances. Moreover, a hybrid approach can also increase cultural resilience with the community. Some limitations of this approach are that it may fail to protect more vulnerable species, such as species that have narrow endemic ranges and decreasing populations (Burnett et. al 2019).

## 3. Integrated Weed Management

An integrated weed management strategy implements both non-chemical and chemical control methods to reduce the overall use of herbicides. This management strategy uses a wide variety of control methods based on the knowledge of known weed biology and ecology.

## 4. Reafforestation

Reafforestation is a long-term technique that involves forming a dense tree canopy to prevent sunlight from penetrating weeds on the ground. This approach can involve planting both native and non-native tree species or focusing on one tree species. This technique can take up to 5 to 10 years, however in Hawai‘i, this approach will likely take longer since native Hawaiian trees typically grow very slowly. Non-chemical and chemical weed control techniques may be used in the meantime to control weeds while establishing the canopy.

## Section 5. Invasive Species Removal and Management Recommendations for Target Sites

### A‘ali‘i Grove

A‘ali‘i Grove has the potential to be one of the most important sites throughout the valley. Due to its easy accessibility, this site can be well managed and used for educational purposes.

#### Recommended Management Strategies

- **Kīpuka style restoration** - Since this site is a natural kīpuka of A‘ali‘i plants, a kīpuka style restoration is highly appropriate for this site. This site can be expanded upon to become a central site of restoration.
- **Integrated weed management** - This would be the best overall approach for weed control because this site will receive many volunteers that can consistently manage weeds using non-chemical techniques. Since this site contains highly invasive plants (i.e. haole koa and Guinea grass), the use of herbicide can also effectively support the volunteer efforts. Applying herbicide will need to occur when no volunteers are present for at least a couple days after application. Also, the best time to apply is during periods of no rain. Since the trail is close to this site, application of herbicide should always be mindful of passing hikers. Lastly, herbicide usage, in general, does not align well with cultural values (e.g. Aloha ‘Āina), so chemical techniques should be used sparingly and appropriately.
- **Hybrid approach** - Since A‘ali‘i Grove will be the main entrance site for Pia Valley, a hybrid approach can be effective for this site. In particular, volunteers will be able to experience how a mixture of native species and cultural plants honors the historical significance of this valley, which will ultimately provide more meaningful connections to the land. Also, community members have expressed a desire to utilize the resources of Pia Valley, so a hybrid approach can provide valuable plants for the community. Lastly, having both native and cultural species can be a great educational approach for students working in Pia Valley.
- **Reafforestation -** Establishing a native canopy cover will support weed control efforts and also provide needed shade for volunteers and school groups.

#### Recommended Invasive Species Removal Techniques

*Non-Chemical Removal Techniques*

- **Hand pulling -** This technique aligns well with cultural and community values because it can be used by community members of all ages. It is also the safest form of weed removal and it can be effective for removing weeds near the established ‘A‘ali‘i plants.
- **Hand/Power tools** - Power tools will be appropriate for cutting back Guinea grass and haole koa. This technique should be operated by volunteers with previous tool experience

since it involves risk of injury. Herbicide may be applied to plants after cutting, however herbicide must be used with caution if people are present at the site.

- **Organic Mulching** - Since A‘ali‘i Grove is located near the entrance of Pia Valley, it is possible for volunteers to haul mulching material to this site. Pitchforks and wheelbarrows will likely be needed for moving mulch. This technique is effective for protecting out planted trees and recently weeded areas.
- **Soil Solarization** - This technique is easily applicable to protect out planted trees and recently weeded areas. Also, transporting solarization materials to this site is practical.

*Chemical Removal Techniques*

- **Clip and Drip** - This technique should be applied to the haole koa plants in the area. After trees are cut (from the use of tools), herbicide should be applied to completely cover the cur area. Since A‘ali‘i Grove is not located near the stream, this method is applicable and should be used during dry days when no volunteers are present.
- **Foliar Spray** - Similar to clip and drip, this technique should be applied to recently cut plants like Guinea grass. This method has the potential to unintentionally spray native or cultural plants, so this technique should not be applied near them.

# Red Slope

Red Slope has the potential to be intensively restored with a diversity of native plants. Soil erosion is a main concern for this area, so steps should be taken to reduce erosion of this site.

## Recommended Management Strategies

**Kīpuka style restoration** - Red Slope contains numerous established native species, so expanding upon these plants will be a great place to start with restoration.

I**ntegrated weed management** - Non-chemical and chemical methods are appropriate because this site contains many different types of invasive species. Non-chemical methods should be used around established plants and also to cut back invasive vegetation. Chemical methods should be applied immediately after cutting and used on invasive tree species and Guinea grass. Lastly, herbicide usage, in general, does not align well with cultural values (e.g. Aloha ‘Āina), so chemical techniques should be used sparingly and appropriately.

## Recommended Invasive Species Removal Techniques

*Non-Chemical Removal Techniques*

- **Hand pulling** - This technique can be used to remove weeds near established native plants.
- **Hand/Power tools** - Power tools will be appropriate for cutting back Guinea grass and other invasive trees. This technique should be operated by volunteers with previous tool

experience since it involves risk of injury. Herbicide may be applied to plants after cutting, however herbicide must be used with caution if people are present at the site.

- **Soil Solarization** - This technique is applicable to protect out planted trees and recently weeded areas. However, transporting solarization materials to this site may be impractical if being used over large areas.

*Chemical Removal Techniques*

- ***Clip and Drip*** - This technique is applicable to plants like Soap bush, Sour bush, Strawberry guava, Octopus tree, and Java plum. After cutting these plants using tools, herbicide should be applied to completely cover the cur area. Red Slope is not located near the stream, so this method is applicable and should be used during dry days when no volunteers are present.
- **Girdling** - This technique should be applied to trees that are too large to be clipped. These include Strawberry guava, Octopus tree, Sourbush, and Java plum. Girdling is also effective for controlling christmas berry.
- **Foliar Spray** - This technique should be applied to Guinea grass. This method has the potential to unintentional spray native or cultural plants so this technique should not be applied near those plants.

## Section 6. Broader Applications

### *Plants for Restoration*

Any strategy to remove invasive species would not be complete without considering the appropriate plants to replace the invasive species. Therefore, Table 3 contains a list of native plants that interviewees deemed are appropriate for Pia Valley ecosystem restoration. Each plant listed below would be appropriate for the two target sites and also the rest of Pia Valley.

| Hawaiian Name | Scientific Name | Medicinal Use | Ground Cover/Canopy |
|---|---|---|---|
| Koa | *Acacia koa* | Bedridden persons | Canopy |
| Hame | *Antidesma pulvinatum* | Phyllanthaceae | Canopy |
| Koʻokoʻolau | *Bidens sandvicensis* | General debility, stimulating appetite, asthma | Ground Cover |
| Lama | *Diospyros hillebrandii* | Ebenaceae | Canopy |
| Lama | *Diospyros sandwicensis* | Ebenaceae | Canopy |
| Aʻaliʻi | *Dodonaea viscosa* | Sapindaceae | Ground Cover/Canopy |
| Wiliwili | *Erythrina sandwicensis* | Fabaceae | Canopy |
| ʻAkoko | *Euphorbia celastroides var. amplectens* | Euphorbiaceae | Ground Cover |
| Palapalai | *Microlepia strigosa var. strigosa* | Dennstaedtiaceae | Ground Cover |
| Kupukupu | *Nephrolepis exaltata subsp. Hawaiiensis* | Lomariopsidaceae | Ground Cover |
| ʻŪlei | *Osteomeles anthyllidifolia* | General debility | Ground Cover |
| Hōʻawa | *Pittosporum glabrum* | Swelling and sores | Canopy |
| ʻIlieʻe | *Plumbago zeylanica* | Plumbaginaceae | Ground Cover |
| ʻOhe makai | *Polyscias sandwicensis* | Araliaceae | Canopy |
| ʻAlaheʻe | *Psydrax odorata* | Rubiaceae | Canopy |
| ʻIliahi | *Santalum ellipticum* | Santalaceae | Canopy |
| Lonomea | *Sapindus oahuensis* | Sapindaceae | Canopy |
| Kolomona | *Senna gaudichaudii* | Fabaceae | Ground Cover |
| ʻIlima | *Sida fallax* | General debility, womb, asthma | Ground Cover |
| Keahi | *Sideroxylon polynesicum* | Sapotaceae | Canopy |

**Table 3.** List of native species suggested for Pia Valley ecosystem

Additionally, interviewees expressed their desire to see culturally important plants in the restoration. As one interviewee said, "*If you know the mo'olelo (Hawaiian story and knowledge) of the place, it almost tells you the different plants that were prevalent there and their different functions of the environment."* Table 4 is a list of suggested plants for Pia Valley based on stories from the interviewees. Note, some plants are also listed for ecosystem restoration.

| Hawaiian Name | Scientific Name | Reasoning |
|---|---|---|
| Koa | *Acacia koa* | Based on the importance of traditional navigation in the area |
| ʻŌhiʻa lehua | *Metrosideros polymorpha* | Based on families' ancestral ties to this plant |
| Wiliwili | *Erythrina sandwicensis* | Based on a special connection to Niu Valley. Also, the leaves are an indicator of certain fish in the ocean |
| ʻAwa | *Piper methysticum* | Based on accounts of the gods Kāne and Kanaloa travelling throughout this Maunalua area |
| Makaloa | *Cyperus laevigatus* | Based on the story of Kaumana (a kupua or demigod) gathering this plant in the coastal areas of Niu |
| Pia | *Tacca leontopetaloides* | Based on the name of the place |

**Table 4.** List of culturally significant plants suggested for Pia Valley

## *Future work in Pia Valley*

Pia Valley has amazing potential for bringing communities together to restore the land. While this restoration guide has focused on two target sites in Pia valley, all of the cultural values, community voices, invasive species removal techniques, and recommendations are applicable for sites throughout the entire valley. In fact, restoration of the two target sites, Aʻaliʻi Grove and Red Slope, is intended to serve as starting points for Pia Valley restoration. The work at these two sites will ultimately improve future restoration efforts because it is a great opportunity to figure out which restoration methods work, and which ones do not.

Additionally, it is imperative to follow the cultural values and community voices shared in this guide. These voices and values come directly from the people of Hawaiʻi, so they should be used to help make more informed and effective management decisions. Future biocultural work in Pia Valley, however, should expand upon these voices and values, which will ultimately lead to greater longer-term restoration success.

There are a few things that were briefly mentioned in this guide that should be researched into the future. Firstly, pigs and other ungulates are a huge problem when it comes to restoring native ecosystems in Hawai‘i. Therefore, future work should investigate the different methods of ungulate fencing for Pia Valley. Fencing is very effective at controlling ungulates, but it can be very expensive. Any information that can help Protect and Preserve Hawai‘i manage ungulates will definitely increase restoration success. Also, in addition to fencing, one interviewee expressed that more plant surveys are needed to better identify the native species throughout the valley. Thus, more data on native species found throughout the area will lead to better protection and restoration of native ecosystems.

In the end, the work in Pia Valley can be a model of restoration success for the other valleys throughout the Maunalua area. Since Maunalua Bay is one of the most beloved places in Hawai‘i, any work that protects and restores the uplands will ensure a healthy Maunalua Bay downstream.

## Section 7. Acknowledgments

On behalf of the students of NREM, we would like to send a big mahalo to the executive director of Protect and Preserve Hawai‘i, Tyrone Montayre. Tyrone’s vision and dedication to restoring Pia Valley gave us the inspiration to write this guide. When people like Tyrone step up and make a difference in their community, the future of our island home can only get better. We hope this restoration guide can not only assist Tyrone and his organization, but also help the rest of the Maunalua Community.

We would also like to thank the many interviewees who dedicated their time and voice to help us create this guide. Each interviewee was an integral part of this guide because they provided the honest input needed for meaningful community engagement. All their stories, insights, and lessons were so valuable, and we hope we have given their words justice.

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## Section 8. References


Beamer K. 2014. “Tūtū’s aloha ‘āina grace” in The Value of Hawai'i 2: Ancestral Roots, Oceanic Visions. *University of Hawaii Press*. Honolulu, HI.

Chang K., Winter K., Lincoln N. 2019. Hawai‘i in focus: navigating pathways in global biocultural leadership. Sustainability. 11(1): 283.

Dacks R., Ticktin T., Mawyer A., Cailon S., Claudet J., Fabre P., Jupiter S., McCarter J., Mejia M., Pascua P., Sterling E., Wongbusarakum S. 2019. Developing biocultural indicators for resource management. *Conservation Science and Practice.* 38.

Handy, E. S. C. "The Hawaiian Planter-Volume I, his plants, methods and areas of cultivation." *The Hawaiian Planter-Volume I, his plants, methods and areas of cultivation.* Bull. 161 (1940).

“Institute of Pacific Islands Forestry Pacific Island Ecosystems at Risk (PIER) Plant Threats to Pacific Ecosystems.” *Pacific Island Ecosystems at Risk (PIER) Home Page*, www.hear.org/pier/index.html.

Kurashima N., Jeremiah J., Whitehead N., Tulchin J., Browning M., Duarte T. 2018. ‘Aina Kaumaha: The Maintenance of Ancestral Principles for 21st Century Indigenous Resource Management. *Sustainability.* 10: 3975.

Kurashima N., Jeremiah J., Ticktin T. 2017. I ka wä ma mua: The Value of a Historical Ecology Approach to Ecological Restoration in Hawai‘i. *Pacific Science.* 71(4): 437-456.

Morishige K., Andrade P., Pascua P., Steward K., Cadiz E., Kapono L., Chong U. 2018. Nā Kilo ‘Āina: visions of biocultural restoration through indigenous relationships between people and place. *Sustainability.* 10: 3368.

Oliveira, Katrina-Ann R. "Kapa’anaokalaokeola Nakoa." *Ancestral Places: Understanding Kanaka Geographies* 1 (2014).

Mueller-Dombois, Dieter. "A silvicultural approach to restoration of native Hawaiian rainforests." *Lyonia* 8.1 (2005): 61-65.

Protect and Preserve Hawaii Management Plan, 2019

“The Army Natural Resources Program on O'ahu.” *Volunteer Opportunities*, 18 July 2019, oanrp.com/about/.

Winter K., Beamer K., Vaughan M., Friedlander A., Kido M., Whitehead N., Akutagawa M., Kurashima N., Lucas M., Nyberg B. 2018. The Moku System: Managing Biocultural Resources for Abundance within Social-Ecological Regions in Hawai‘i. *Sustainability.* 10: 3554.

## Section 8. List of Figures and Tables